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Cryo Testing of Coated SBMD Mirror

Ball Aerospace & Technologies, Inc.

23 May 2002

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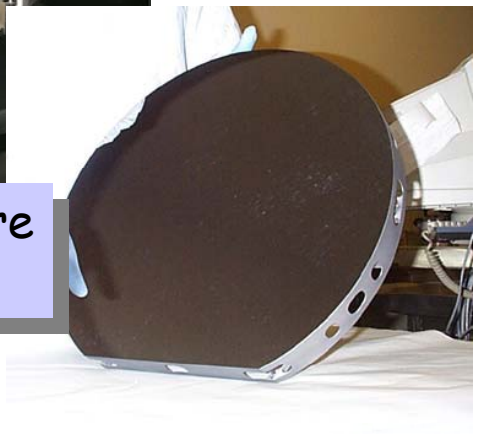
SBMD Met All Requirements - Areal Density and Optical Cryo Performance

0.53-m diameter, 20 m RoC



19 nm rms figure at 38K

- SBMD Program successfully completed
  - Final briefing & test report, November 2000
- Beryllium substrate has excellent properties
  - Areal density < 9.8 kg/m^2
  - High stiffness-to-mass for acceptable 1-g testing
- Excellent optical performance at cryogenic temperatures demonstrated
  - Successfully tested from ambient down to 17K at MSFC
    - ambient to cryogenic surface figure shift < 89 nm rms
    - Stable cryo-figure < 19 nm rms
    - Print through < 6 nm rms

SBMD Used to Examine Coating Distortion Effects

- Original SBMD program did not look at effects of cryo temperatures on coated mirrors
  - Task: Apply a protected gold coating to SBMD and retest at cryo
- To isolate the coating effects, the mount was modified to reduce cryo-figure mount induced distortion
  - Task: Modify mounting to:
    - Reduce mount induced cryo-figure distortion
    - Reduce variability after handling and cryo-cycling

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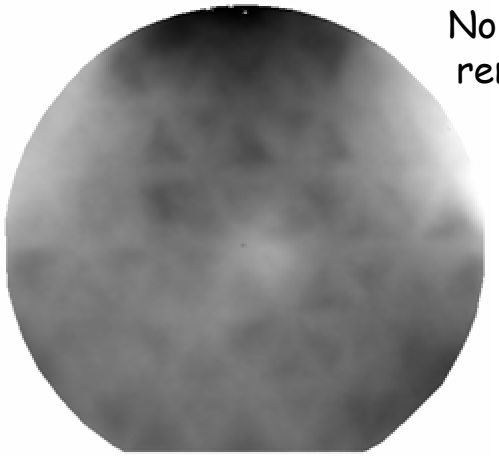
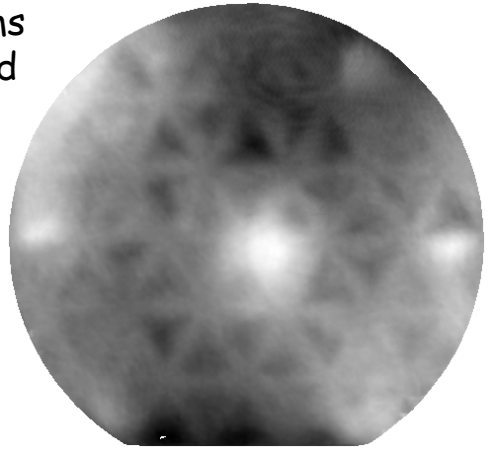
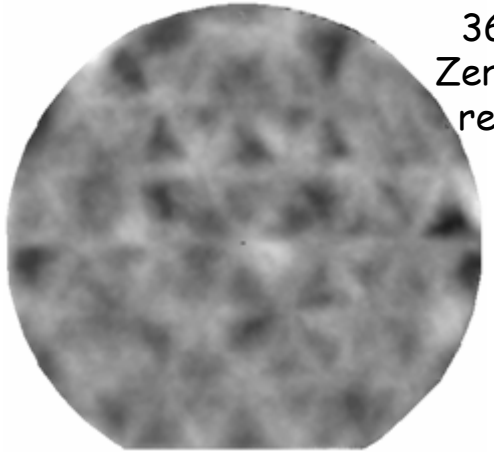
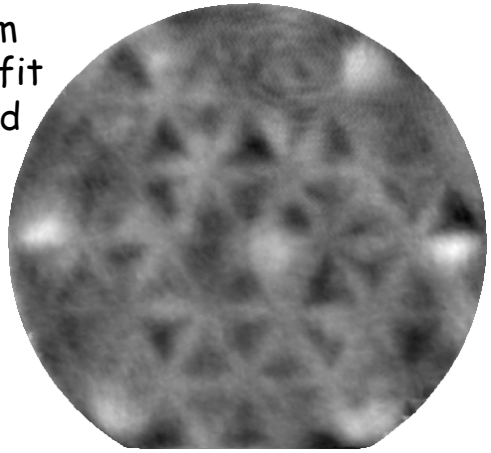
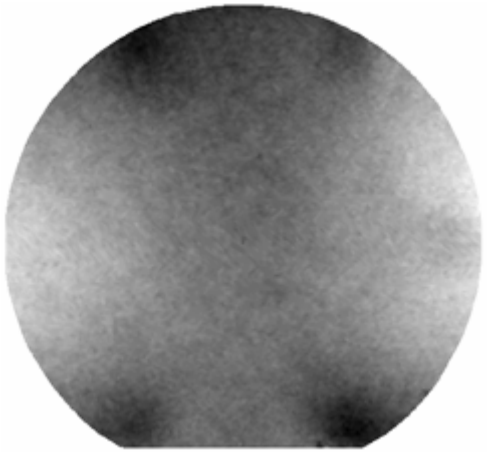
Modified Mounting System Stable and Lowered Cryogenic Distortion

SBMD

Original Mount		New Mount
	No terms removed	
Surface Change = 89 nm rms		**Surface Change = 53 nm rms**
	36 term Zernike fit removed	
Surface Change = 17 nm rms		**Surface Change = 17 nm rms**

Residual pattern with new mount shows the amount of cryo-distortion from the original mount that was removed by cryo-figuring and now no-longer shows up with new mount



Surface Change = 11 nm rms

Measured change in ambient surface figure, before and after last cryogenic test, 6-rotation average

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Protected Gold Coating Successfully Applied to SBMD

- Mirror coated 6/7/01 at Denton Vacuum Inc.
  - Protected gold coating (coating is beautiful)
  - Coating passes humidity, adhesion and abrasion
    - Samples coated concurrent with mirror
  - Coating passed cryogenic shock test
    - Coated beryllium discs dunked in LN2
    - Passed tape test & no crazing after cryogenic shock
  - Coating calibration samples showed excellent uniformity

- Mirror shipped to MSFC for ambient optical testing
- Performed Cryogenic characterization

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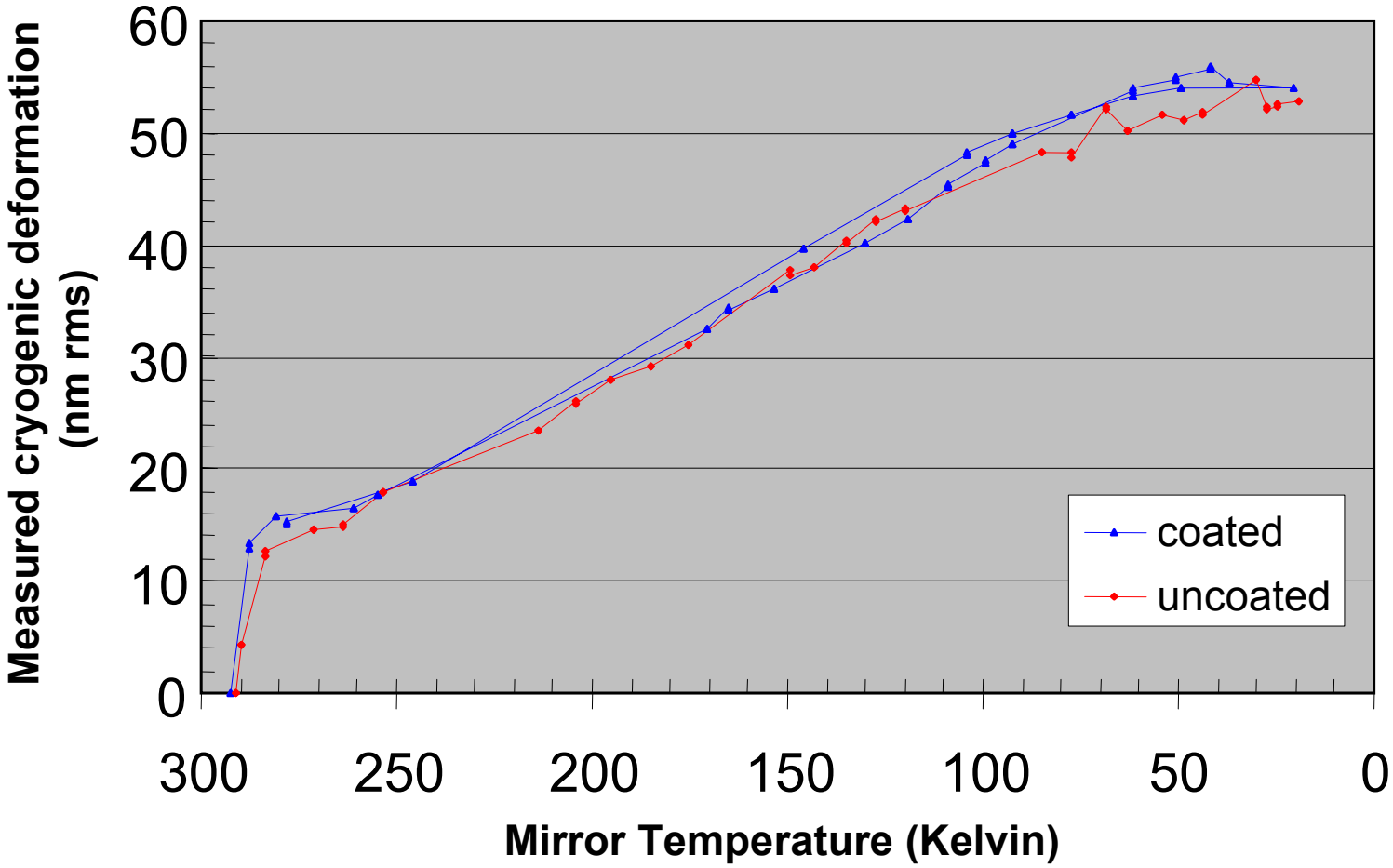
Cryogenic Deformation of SBMD Small and Repeatable Before and After Coating



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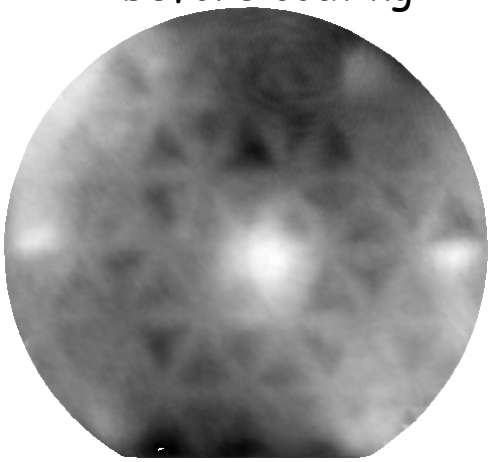
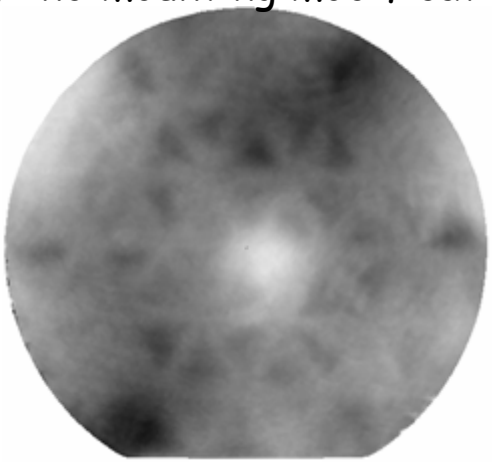
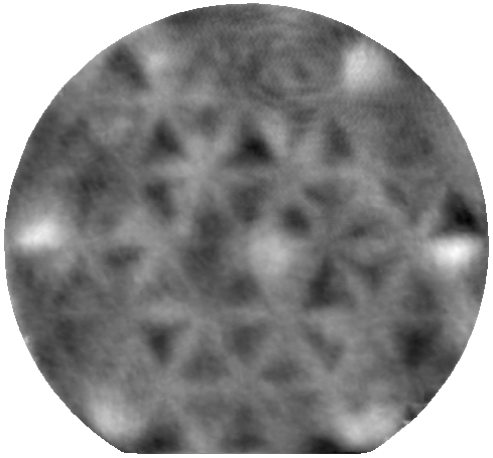
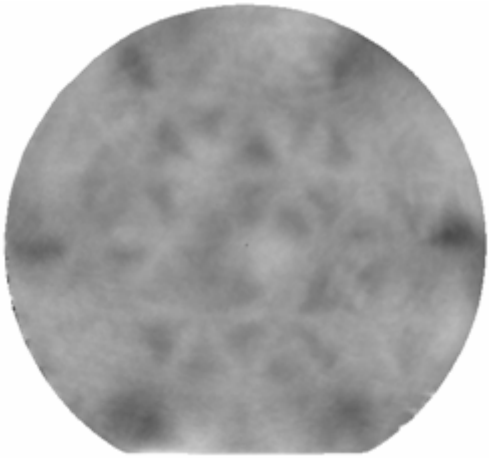
Cryogenic Deformation Before and After Coating Shows Little Change

SBMD

	Cryogenic deformation before coating	Cryogenic deformation after coating & 2nd mounting modification
No terms removed →		
	Surface Change = 53 nm rms	Surface Change = 54 nm rms
36 term Zernike fit removed →		
	Surface Change= 17 nm rms	Surface Change = 23 nm rms

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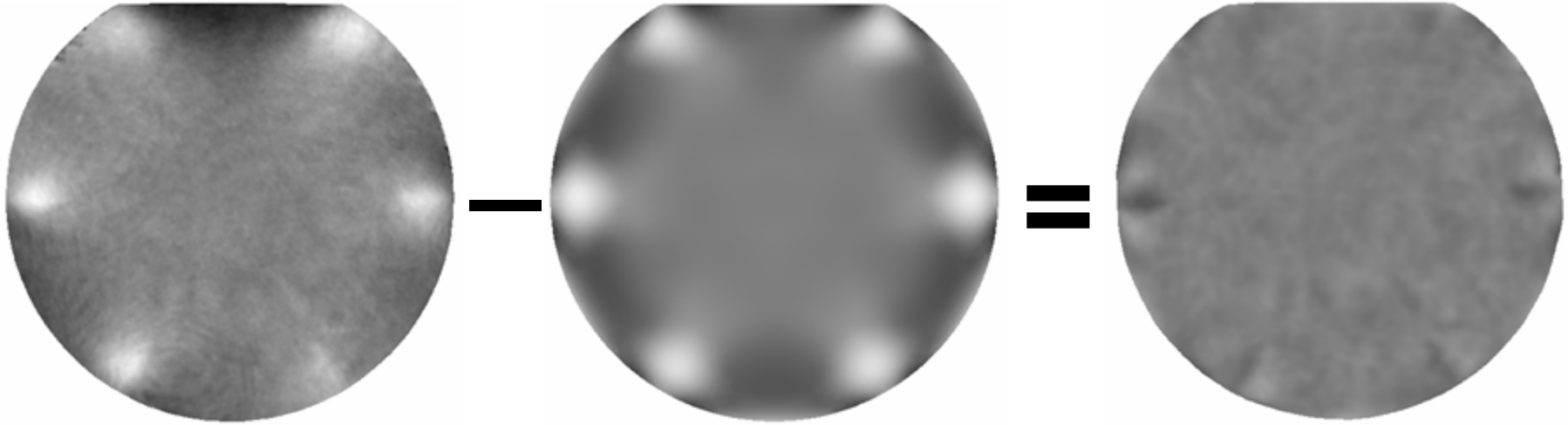
Most of Change in Cryogenic Deformation Due to Modified Mounting



Change between cryogenic deformation before and after coating and modification of mounting
Surface Change = 35 nm rms

NASTRAN prediction for modified mounting change
Surface Change = 35 nm rms

Best estimate of only the coating effects
Surface Change = 9 nm rms

Measured coating plus mounting effects minus the NASTRAN predicted mounting effect.

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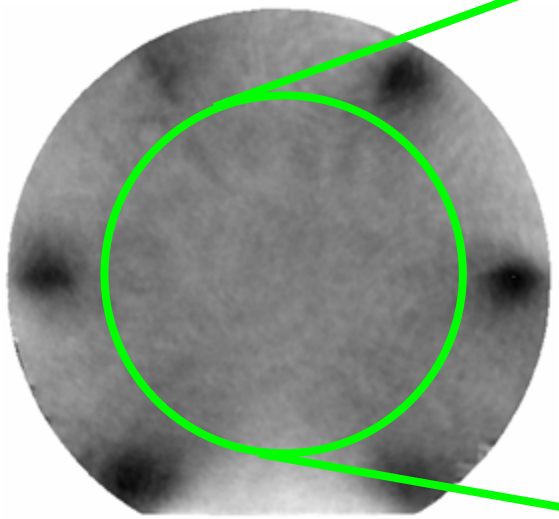
Change in Cryogenic Deformation as a Result of Gold Coating

SBMD

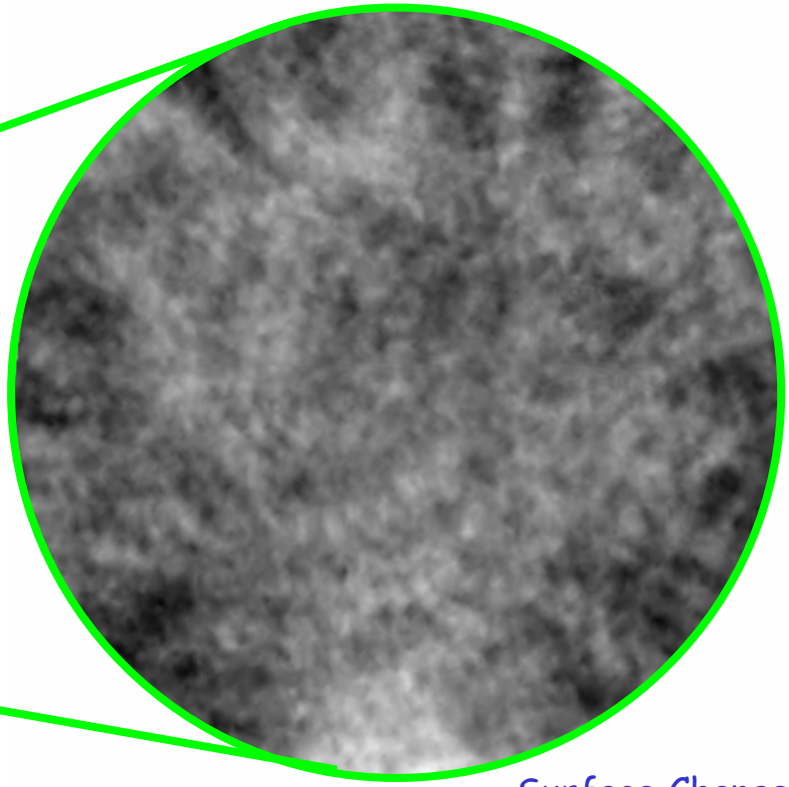
Mounting modification produced star-shaped residual pattern in previously cryo-figured mirror

Inner portion of difference map shows that coating of SBMD had no effect on the higher frequency print through measured in all previous SBMD tests



Surface Change = 35 nm rms

Change in cryogenic deformation after coating and mount modification



Surface Change = 9 nm rms

Change in measured cryogenic deformation over central 300 mm diameter region after coating and mount modification

Summary of Additional SBMD Investigations

- New bipods
  - Resulted in significantly lower cryogenic distortion
    - 89 nm rms mounted to original flexure system
    - 53 nm rms mounted to new flexure system
  - Improved pre/post cryogenic test repeatability
- Coating
  - Proved negligible impact on ambient surface figure
  - Proved negligible impact on cryogenic surface figure
    - 53 nm rms cryogenic distortion before coating
    - 54 nm rms cryogenic distortion after coating
  - Proved negligible impact on cryogenic print through
    - < 9 nm rms change in high frequency component